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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

Ref: 8EPR-SR August 2, 2010

MEMORANDUM

SUBJECT: Libby Asbestos Site, Operable Unit 3
Draft Interim Ecological Risk Assessment

FROM: Bonnie Lavelle
Remedial Project Manager
Libby Asbestos Site, OU3

TO: Site File

The attached document was prepared by the EPA contractor SRC, Inc.; under contract number GS-00F-0019L, task order 0843 to fulfill the scope of work requirement to prepare a draft Interim Baseline Ecological Risk Assessment Report.

BASELINE ECOLOGICAL RISK ASSESSMENT

for

OPERABLE UNIT 3
LIBBY ASBESTOS SUPERFUND SITE

Prepared for, and with oversight by:
U.S. Environmental Protection Agency, Region 8
1595 Wynkoop Street
Denver, Colorado 80202

Prepared by:
SRC, Inc.
999 18th Street, Suite 1975
Denver, Colorado 80202

July 8, 2010

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LIST OF ACRONYMS

BTAG	Biological Technical Assistance Group
cc	Cubic Centimeter
cfs	cubic feet per second
COC	Chain of Custody
COPC	Chemicals of Potential Concern
CSM	Conceptual Site Model
DO	Dissolved Oxygen
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
EDS	Energy Dispersive Spectroscopy
FS	Feasibility Study
GI	Gastrointestinal
GRAV	Gravimetric
ha	hectare
HQ	Hazard Quotient
HQmax	Maximum Hazard Quotient Value
IMEE	In-Situ Measures of Exposure and Effects
ISO	International Organization for Standardization
KDC	Kootenai Development Corporation
LA	Libby Amphibole
MDEQ	Montana Department of Environmental Quality
MFL	Million Fibers per Liter
MMU	Minimum Map Unit
MNHP	Montana National Heritage Program
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCDO	Population and Community Demographic Observations
PCM	Phase Contrast Microscopy
PEC	Probable Effect Concentration
PLM	Polarized Light Microscopy
PLM-VE	Polarized Light Microscopy Visual Area Estimation Method
PLM-PC	Polarized Light Microscopy Point Count Method
RBP	Rapid Bioassessment Protocol
RI	Remedial Investigation
SAED	Selective Area Electron Diffraction
SAP	Sampling and Analysis Plan
SEM	Scanning Electron Microscopy
SOP	Standard Operating Procedure
SSTT	Site-Specific Toxicity Tests

SVOC	Semi-Volatile Organic Chemical
TEC	Threshold Effect Concentration
TEH	Total Extractable Hydrocarbons
TEM	Transmission Electron Microscopy
TPH	Total Petroleum Hydrocarbons
TM	Thematic Mapper
TRV	Toxicity Reference Value
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
VOC	Volatile Organic Chemical
VPH	Volatile Petroleum Hydrocarbons
WHO	World Health Organization

INTRODUCTION

1.1. Purpose of This Document

This document is a Baseline Ecological Risk Assessment (BERA) for Operable Unit 3 (OU3) of the Libby Asbestos Superfund Site, located near Libby, Montana. The purpose of the BERA is to describe the likelihood, nature, and extent of adverse effects in ecological receptors in OU3 that result from exposure to asbestos and other non-asbestos contaminants released to the environment of OU3 as a result of past mining, milling and processing activities at the site. This information, along with other relevant information, is used by risk managers to decide whether remedial actions are needed to protect ecological receptors in OU3 from site-related contaminantion.

1.2 Overview of the Ecological Risk Assessment Process

This BERA was performed in general accordance with current United States Environmental Protection Agency (EPA) guidance for ecological risk assessments (EPA 1992, 1997, 1998).

Figure 1-1 outlines an eight-step process that EPA recommends for guiding ecological risk assessments art Superfund sites (EPA 1997). It is important to realize that the steps shown in Figure 1-1 are not intended to represent a linear sequence of mandatory tasks. Rather, some tasks may proceed in parallel, some tasks may be performed in a phased or iterative fashion, and some tasks may be judged to be unnecessary at certain sites.

The first two steps are screening-level evaluations that are intentionally simplified and conservative, and usually tend to overestimate the amount of potential risk. This allows for the elimination of those factors that are not associated with significant ecological risk, allowing subsequent efforts to focus on factors that are of potential concern. The remaining steps are intended to support the development of the baseline assessment. This includes the process of problem formulation (Step 3), collection of data needed to support the baseline assessment (Steps 4-6), evaluation and interpretation of the data (Step 7), and use of the data to make risk management decisions (Step 8).

1.3 Document Organization

In addition to this introduction, this report is organized into the following main sections.

- Section 2 - This section describes the location, history, and environmental setting of Operable Unit 3.
- Section 3 - This section presents the ecological problem formulation, including the site conceptual models for asbestos and other contamninats, the selection of assessment and

measurement endpoints, and a description of the basic methods used in the baseline assessment.

- Section 4 - This section presents the ecological risk characterization for exposure of environmental receptors to asbestos from the mine.
- Section 5 - This section presents the ecological risk characterization for exposure of receptors to other (non-asbestos) contaminants from the mine.
- Section 6 - This section provides citations for all data, methods, studies, and reports utilized in the BERA.

SITE CHARACTERIZATION

2.1. Overview

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. The mine location is shown in Figure 2-1.

Vermiculite from the mine contains a form of asbestos referred to as Libby Amphibole (LA). This site is of potential concern to EPA because historic mining, milling, and processing of vermiculite at the site are known to have caused releases of vermiculite and LA to the environment. Inhalation of LA associated with the vermiculite is known to have caused a range of adverse health effects in exposed humans, including workers at the mine and processing facilities (Amandus and Wheeler 1987, McDonald et al. 1986, McDonald et al. 2004, Sullivan 2007, Rohs et al. 2007), as well as residents of Libby (Peipins et al. 2003). Exposure to asbestos released to the environment may also be having adverse effects of aquatic and/or terrestrial wildlife near the mine. Based on these concerns, EPA listed the Libby Asbestos Superfund Site on the National Priorities List in October 2002.

Given the size and complexity of the Libby Superfund Site, EPA divided the site into a series of Operable Units (OUs). This document focuses on OU3. This OU includes the property in and around the former vermiculite mine and the geographic area surrounding the mine that has been impacted by releases and subsequent migration of hazardous substances and/or pollutants or contaminants from the mine. A preliminary study area boundary for OU3 is shown by the red line in Figure 2-1. This study area encompasses the forested area surrounding the mine, and includes all of the major surface water features in OU3. EPA established this preliminary study area boundary for the purpose of planning and developing the initial scope of the Remedial Investigation (RI) for OU3. This preliminary boundary may be revised as data are acquired on the extent of environmental contamination associated with releases that may have occurred from the mine site.

2.2 Physical Setting

Land Use

The terrain in OU3 is mainly mountainous with dense forests and steep slopes. Current land ownership in the area is shown in Figure 2-2. Kootenai Development Corporation (KDC), a subsidiary of W.R Grace & Co., owns the mine area and the immediately adjacent portion of the off-mine area. The majority of the surrounding land is owned by the United States government and is managed by the Forest Service, with some land parcels owned by the State of Montana and some owned by Plum Creek Timberlands LP for commercial logging.

Climate

Northern Montana has a climate characterized by relatively hot summers, cold winters, and low precipitation. Table 2-1 presents climate data collected at the Libby NE Ranger Station, which is located just west of the town of Libby near the Kootenai River. Average summer high temperatures (^{o}F) are in the upper 80s, and low temperatures are in the 40s, while winter highs are in the 30s and lows are in the teens. The western mountain ranges cause Pacific storms to drop much of their moisture before they reach the area, resulting in relatively low precipitation, averaging about 18 inches per year. The most abundant rainfall occurs in late spring/early summer. In the winter months, snowfall averages 54 inches each year and snow cover typically remains on the ground from November through March. Data collected from a weather station at the mine site indicate that winds are predominantly to the northeast (Figure 2-3). Wind speed collected from January 2007 through xxxx [update based on latest windrose from Remedium] exceeded 30 mph for three measurements collected over two days in February. Only about 2% of the measurements collected during this period were above 20 mph, and most of the time the wind speed ranged from about 1-10 mph.

Surface Water Features

The mine is located within the Rainy Creek watershed, an area of approximately 17.8 square miles. Figure 2-4 shows the main surface water features of OU3. Primary surface water bodies include:

- <u>Rainy Creek</u> originates between Blue Mountain and the north fork of Jackson Creek at an elevation of about 5,000 feet, and falls to an elevation of 2,080 feet at the confluence with the Kootenai River (Zinner 1982). The average gradient for Rainy Creek is about 12% (Parker and Hudson 1992), and the banks are well vegetated (MWH 2007).

- <u>Fleetwood Creek</u> flows westward along the north of the mined area (Figure 2-4). The average stream gradient for Fleetwood Creek is about 11% (Parker and Hudson, 1992). Under current site conditions, Fleetwood Creek flows through a portion of mine waste before flowing into a large tailings impoundment which was constructed within the former Rainy Creek channel (see below). A small ponded area was identified along Fleetwood Creek during reconnaissance surveys by EPA in 2007. This area is devoid of vegetation (Figure 2-xx).

- <u>Carney Creek</u> flows westward along and through mine waste on the south side of the mined area before joining Rainy Creek. During an aerial survey in 2008, a small pond was discovered on Carney Creek (Figure 2-x). This pond was formed when waste piles were deposited in the drainage and blocked and altered the flow of the creek. The pond is vegetated on one side. Several small springs are reported along Carney Creek (Zinner, 1982) and were identified during reconnaissance surveys by EPA in 2007 (Figure 2-x).

- Tailings Impoundment. In 1972, W.R. Grace & Co. constructed a tailings impoundment that received the discharge of process waters that had previously been directly discharged to Rainy Creek. The impoundment was built to provide for settlement of fine tails produced by a new milling (wet) process and to recover water for reuse. The height of the dam which forms the impoundment is about 135 feet measured from the downstream toe. The impoundment occupies 70 acres (Figure 2-xx). The impoundment receives input from both upper Rainy Creek and Fleetwood Creek (Figure 2-4). The impoundment drains through a toe drain directly into Rainy Creek, and may also discharge to Rainy Creek via an overflow channel during high flow events (Parker and Hudson, 1992).

- Mill Pond. A pond in the Rainy Creek channel downstream of the tailings impoundment was constructed to provide a water supply for mining operations. The pond discharges to Rainy Creek where it mixes with flow from Carney Creek and flows downstream to the Kootenai River. This reach has some seasonal gain in flow, most likely due to groundwater input (EPA, 2007).

- Kootenai River. The Kootenai River flows from east to west along the south side of the site. Flows in the Kootenai River are controlled by the Libby Dam, which was constructed in the late-1960s and early-1970s as part of the Columbia River development for flood control, power generation, and recreation. Daily water outflow plans[1] for October 2006 through August 2007 show lowest discharge flows in March and October at approximately 4,000 cubic feet per second (cfs) and maximum discharge flows in late May/early June at 26,600 cfs.

2.3 History of Mining Activities at the Site

The mine is located in a region of the Precambrian Belt Series of northwestern Montana that has been intruded by an alkaline-ultramafic body. The Rainy Creek Igneous Complex comprises the upper portion of this intrusion. Hydrothermal alteration of the biotite pyroxenite intrusion produced the large, high-quality vermiculite deposit. The vermiculite content of the ore varies considerably within the deposit, ranging from 30 to 84%.

Figure 2-5 shows the current mine features and location of historical mining buildings. The mine was operated from 1923 until 1990. The mine was operated as an open pit except for a short period in the early period of operations. The mine area is heavily disturbed by past mining activity and some areas remain largely devoid of vegetation. There are a number of areas where mine wastes have been disposed (Figure 2-5), including waste rock dumps (mainly on the south side of the mine), coarse tailings (mainly to the north of the mine), and fine tailings (placed in the tailings impoundment on the west side of the site).

[1] Available from http://www.nwd-wc.usace.army.mil/ftppub/project_data/yearly/lib_wy_qr.txt

The basics of ore processing did not change over the period of operation, although unit operations were changed as ore quality decreased and technology improved, and in response to concerns over dust generation (Zucker, 2006). In general, rock was removed to allow access to the vermiculite or separated from the vermiculite in the mine pits and dumped over the edge to form waste rock piles (see Figure 2-5). After 1971, ore was processed to separate out vermiculite product by crushing, screening or water floatation, with those operations generally occurring in the mill area (Figure 2-5).

A storage and loading facility along the river at the mouth of Rainy Creek was built in 1949. It included a 600-foot conveyor belt for carrying material across the Kootenai River, and a loading facility along the Great Northern Railroad tracks on the south side of the river.

A new concentrating plant began operations in 1954 in the general milling area (Figure 2-5). This plant was designed to separate the vermiculite from ore that contained less than 35% vermiculite. Continued refinements led to implementation of a wet process, in which a froth flotation process was coupled with shaking tables to separate waste rock from the vermiculite. The dry mill continued to operate. After passing through a two-inch grizzly, ore went to one of five storage bins at the mill. Ore was blended and sent to the primary screens at the mill where water was added. Oversize material was concentrated in jigs and dried in rotary driers. The material was then crushed using hammer mills and roll crushers before being screened, with finer material further separated using spiral concentrators. Material was then dewatered and dried before being screened for product. The process generated two types of waste material; coarse tailings which were disposed in a pile to the north (Figure 2-5) and fine tailings which appear to have been discharged to Rainy Creek until a tailings impoundment was constructed in 1971.

W.R. Grace & Co.-Conn. (then known as W.R. Grace & Co.) took over mining in 1963. In 1971, they undertook a major expansion to increase capacity and improve the beneficiation process. It was at this time that the tailings impoundment was built to provide for settlement of the fine tailings produced by the new process and to recover water for reuse (Schafer, 1992). The dam was designed and constructed in stages, with a 50 foot high starter dam constructed in 1971, immediately downstream of an older, existing dam. Additional construction phases in 1975, 1977, and 1980 raised the top of the dam to a total height of 135 feet measured from the downstream toe.

Remedium reviewed historic information on mining operations at the site and reported that in a typical year about 5 million tons of rock was mined to generate 220,000 tons of vermiculite product. Primary waste materials were waste rock (3.5 million tons per year) and tailings (1.1 million tons per year), with lesser amounts of oversize rock and screening plant concentrate wastes. As higher quality ores were depleted and lesser quality ores were mined, various reagents were used to facilitate the separation. Reported reagents include #2 Diesel Fuel (typically between 1.2 and 5.4 million pounds per year), Armeen T (Tallow Alkyl Amine;

100,000 to 500,000 pounds per year), fluorosilicic acid (50,000 to 240,000 pounds per year) and lesser quantities of flocculants, defoamers, frothers and other reagents.

2.4 Asbestos at the Site

Fibrous and asbestiform amphiboles are present in association with the vermiculite ore. A significant portion of the fibrous amphiboles are located along cross-cutting veins and dikes and in the altered pyroxenite wall rock adjacent to them. The alteration zones, dikes, and veins range are found throughout the deposit, and range from a few millimeters to several meters in thickness. Amphibole content in the alteration zones of the deposit is estimated to range between 50-75%. The U.S. Geological Survey (USGS) performed electron probe micro-analysis and X-ray diffraction analysis of 30 samples obtained from the exposed asbestos veins to identify the type of amphibole asbestos present in the mine (Meeker et al. 2003). The results indicated that a variety of amphiboles exist at this site, including winchite, richterite, tremolite, and magnesioriebeckite. The EPA refers to this mixture of amphibole asbestos minerals as Libby Amphibole asbestos (LA).

2.5 Ecological Setting

2.5.1 Terrestrial Habitats and Plant Species

Most of OU3 is forested, with only 4% of the land being classified as non-forest or water (USDAFSR1, 2008; Figure 2-6). Data for the National Forest indicate Douglas-fir forest type is the most common, covering nearly 35 percent of the National Forest land area. Next in abundance are the lodgepole pine forest type and spruce-fir forest type at 17 percent each, and the western larch forest type at 11 percent. Other species reported in the area are the Black Cottonwood (*Populus trichocarpa*), Quaking Aspen (*Populus tremuloides*), Western Paper Birch (*Betula papyrifera var. occidentalis*) and Pacific Yew (*Taxus brevifolia*) (USDAFSR1, 2008).

Specific vegetative surveys of the Libby OU3 mine site are not available. Therefore, an initial vegetative cover map was created using existing information from the analyses of remote sensing data. In 1998, the Wildlife Spatial Analysis Lab at the University of Montana in Missoula created the *Montana Land Cover Atlas* as part of the Montana Gap Analysis Project (Fisher et al., 1998). Data from this project classifies 50 land cover types. The group developed the classification based on the hierarchical design of Anderson et al. (1976) in the same manner as was accomplished in Wyoming (Merrill et al. 1996). Land cover types were targeted and defined according to known occurrences in the state and from classifications used for GAP projects in both Idaho (Caicco et al. 1995) and Wyoming (Merrill et al., 1996). The final list of 50 land cover types is shown in Table 2-3. Vegetative cover on and in the vicinity of the Libby OU3 Site is provided as Figure 2-7. The map is generated from Landsat Thematic Mapper (TM) data covering Montana. Upland cover types were mapped to 2 hectare (ha) minimum map unit

(MMU). Based on this mapping, the vegetative cover around the mine site is predominantly Douglas-fir, lodgepole pine and mixed mesic forest.

2.5.2 Aquatic Species

Rainy Creek Watershed

Within the Rainy Creek watershed there are streams and ponds that provide habitat for aquatic species including plants, invertebrates, amphibians, and fish.

The Montana National Heritage Program (MNHP) lists 25 species of fish that are expected to occur in the area. Of these, 12 are considered to be possible inhabitants of waters in the Rainy Creek watershed. These species include brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), Columbia River redband trout (*Oncorhynchus mykiss gairdneri*), fathead minnow (*Pimephales promelas*), largescale Sucker (*Catostomus macrocheilus*), longnose dace (*Rhinichthys cataractae*), longnose sucker (*Catostomus catostomus*), mottled sculpin (*Cottus bairdi*), mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus mykiss*), torrent sculpin (*Cottus rhotheus*), and westslope cutthroat trout (*Oncorhynchus clarkii lewisi*). The Montana Fish Wildlife and Parks reports that the westslope cutthroat trout is a year round resident in both upstream Rainy Creek and upstream Carney Creek.

It is possible that some of the ponds and impoundments in the Rainy Creek watershed might support some other species of fish that are not expected to occur in high grade mountain streams, but no data have been located on this issue.

Kootenai River

EPA's Environmental Monitoring and Assessment Program (EMAP) has collected aquatic community data at a station on the Kootenai River about one mile downstream of the confluence with Rainy Creek. This location was sampled in August 2002. Forty-four species of aquatic invertebrates have been observed, including oligocheates, insects (diptera, ephemeroptera, trichoptera and hemiptera), colenterates (hydra), mollusks, and nematodes (see Table 2-4). Eleven species of fish were observed (Table 2-5). Mountain whitefish were most common, along with several species of salmonids (rainbow trout, sockeye salmon, cutthroat trout, bull trout) and several species forage fish (dace, shiner, sculpin).

2.5.3 Wildlife Species on or Near the Libby OU3 Site

The Montana Natural Heritage Program is a source for information on the status and distribution of native animals and plants in Montana. An assessment of which wildlife species are expected to occur at the Libby OU3 site was performed based on the Montana Natural Heritage Program Animal Tracker (http://nhp.nris.mt.gov/Tracker/). First, all species known to occur within

Lincoln County, Montana, were identified. Next, the Montana Natural Heritage Program and Montana Fish, Wildlife and Parks Animal Field Guide (http://fieldguide.mt.gov/) was consulted to identify if a particular species was observed near the Libby OU3 Site. Species not identified within the vicinity of OU3, and those not expected to occur at OU3 based on a consideration of available habitat, were removed. The species that remained are listed in Attachment A, along with information on general habitat requirements, habitat type for foraging and nesting, feeding guild, typical food, migration and hibernation, longevity, home range and size. The oldest recorded sighting and latest (year), and the number of individuals identified was also recorded.

The species identified as residing within Libby OU3 include 29 invertebrates (26 terrestrial and 3 aquatic), 7 amphibians, 7 reptiles, 175 birds, and 48 mammals.

2.5.4 Federal and State Species of Special Concern

There are six federally listed protected species that have been reported to occur in or about the vicinity of the Libby OU3 Site, including 2 fish, 1 bird, and 3 mammals. These are listed in Table 2-6. Species of concern to the State of Montana that have been observed to occur in the vicinity of Libby OU3 Site are listed in Table 2-7. This includes 2 amphibians, 7 birds, 4 mammals, 3 fish, and 7 invertebrates. However, not all of these species are equally likely to occur within the OU. Based on an evaluation of where the species was reported within Lincoln County (proximity to OU3), the following listed species are considered to be the most likely to occur in the OU:

- Coeur d'Alene Salamander (*Plethodon idahoensis*)
- Boreal Toad, Green (also known as Western Toad) (*Bufo boreas*)
- Flammulated Owl (*Otus flammeolus*)
- Northern Goshawk (*Accipiter gentilis*)
- Bull Trout (*Salvelinus confluentus*)
- Torrent Sculpin (*Cottus rhotheus*)
- Westernslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*)
- White Sturgeon (*Acipenser transmontanus*) (Kootenai River Pop.)
- Grizzly bear (*Ursus arctos horribilis*)
- Canada lynx (*Lynx canadensis*)

3.0 PROBLEM FORMULATION

Problem formulation is a systematic planning step that identifies the major concerns and issues to be considered in an ecological risk assessment, and describes the basic approaches that will be used to characterize ecological risks that may exist (EPA 1997). As discussed in EPA (1997), problem formulation is generally an iterative process, undergoing refinement as new information and findings become available.

3.1 Conceptual Site Model

A Conceptual Site Model (CSM) is a schematic summary of what is known about the nature of source materials at a site, the pathways by which contaminants may migrate through the environment, and the scenarios by which receptors may be exposed to site-related contaminants. When information is sufficient, the CSM may also indicate which of the exposure scenarios for each receptor are likely to be the most significant, and which (if any) are likely to be sufficiently minor that detailed evaluation is not needed.

Figure 3-1 presents the CSM for exposure of each general ecological receptor group (fish, benthic invertebrates, terrestrial plants, soil invertebrates, birds and mammals and amphibians) to non-asbestos mining-related contaminants. As seen, each receptor group may be exposed by several different pathways. However, not all pathways are equally likely to be important. In this CSM, pathways are divided into three main categories:

- A solid black circle (●) represents pathways that are believed to be complete, and which may provide an important contribution to the total risk to a receptor group.

- An open circle (○) represents an exposure pathway that is believed to be complete, but which is unlikely to be a major contributor to the total risk to a receptor group, at least in comparison to one or more other pathways that are evaluated.

- An open box represents an exposure pathway that is believed to be incomplete (now and in the future). Thus, this pathway is not assessed.

Figure 3-2 presents the CSM for exposure to asbestos. This CSM is similar to the one for non-asbestos (Figure 3-1), except that information is not generally available to characterize the relative importance of each of the various pathways by which a receptor may be exposed. For this reason, the open circle is only used for direct contact (dermal exposure) of birds and mammals with asbestos. However, it should still be understood that not all of the exposure pathways indicated by a black circle for a receptor are likely to be of equal concern.

The following sections provide a more detailed discussion of the main elements of these CSMs.

3.1.1 Potential Sources of Contamination

The main sources of asbestos contamination at this site are the mine wastes generated by historic vermiculite mining and milling activities. This includes piles of waste rock and waste ore at on-site locations, as well as the coarse tailings pile and the fine tailings impoundment. These wastes may also be sources of metals and other inorganic constituents of the ore. In addition, some chemicals used at the mine site in the processing of vermiculite ore might also be present in onsite wastes, including diesel fuel, alkyl amines, fluorosilicic acid, and various other flocculants, defoamers, frothers and other reagents.

3.1.2 Migration Pathways in the Environment

From the sources, contaminants may be released and transported via airborne emissions, surface water transport or food chain transport.

> *Airborne Transport.* Contaminants may become suspended in air and transported from sources via release mechanisms such as wind, mechanical disturbances and/or erosion. Once airborne, contaminants may move with the air and then settle and become deposited onto surface soils. This pathway is likely to be important for asbestos, but is thought to be of low concern for non-asbestos contaminants.
>
> *Surface Transport.* Contaminants may be carried in surface water runoff (e.g., from rain or snowmelt) from the mine or other areas where soil is contaminated, and become deposited in soils or sediments at downstream locations. This pathway is equally applicable to both asbestos and non-asbestos contaminants.
>
> *Food Chain Transport.* Contaminants may be taken up from water, sediment or soil into the tissues of aquatic or terrestrial organisms from water and/or sediment and/or soils and/or prey items into prey items (fish, benthic invertebrate, plants, soil invertebrates, birds, mammals). This is applicable to both asbestos and non-asbestos contaminants.

3.1.3 Potentially Exposed Ecological Receptors

As discussed in Section 2.3, there are a large number of ecological species that are likely to occur in OU3 and that could be exposed to mine-related contaminants. However, it is generally not feasible or necessary to evaluate risks to each species individually. Rather, it is usually appropriate to group receptors with similar behaviors and exposure patterns, and to evaluate the risks to each group.

For aquatic receptors, organisms are usually evaluated in two groups:

- Fish
- Benthic macroinvertebrates

For terrestrial receptors, organisms are usually grouped into five broad categories:

- Plants
- Soil invertebrates
- Birds
- Mammals
- Amphibians

Screening assessment usually begins by assessing risks to each group as a unit, using a sensitive member of the group as an indicator species. In cases where risks appear to be above a level of concern for a large group (e.g., birds, mammals), it may sometimes be useful to divide the groups into smaller sub-groups to allow a more refined assessment. For example, when needed, birds and mammals may be stratified into a number of feeding guilds. Based on the information regarding the types of birds and mammals that are present at this site, the following feeding guilds may be useful if a refined assessment is required for an assessment of wildlife populations at the site.

- *Invertivorous Wildlife* – Invertivorous wildlife consume primarily soil invertebrates and are important in nutrient processing and energy transfer within the terrestrial environment. Insectivorous birds and bats are also important in the control of populations of emerging aquatic insects. These animals also are important food sources for other mammals and birds (carnivores). This group of receptors can be further subdivided according to where and how the organism feeds on invertebrates. Some avian species are *aerial invertivores* feeding on insects in flight. Other avian and mammalian species feed primarily on invertebrates in trees (*arboreal insectivores*).

- *Herbivorous Wildlife* – Herbivorous wildlife consume primarily plant material and are important in nutrient processing and energy transfer within the terrestrial environment. Small herbivorous mammals are important food resources for other mammals and birds (carnivores). This group of receptors can be further subdivided into those species that consume primarily fruit (*frugivores*), nectar (*nectaravores*), or grain (*grainivores).* In particular, avian species that consume nectar are important in the pollination of plants. Granivorous mammals and birds are important in the dispersal of plants as well as nutrient processing and energy transfer. They also serve as food resources for other mammals and birds (*carnivores*).

- *Omnivorous Wildlife* – Omnivorous wildlife consume both plant and animals. They are also important in nutrient processing and energy transfer within the terrestrial environment and may serve as food resources for carnivores. Most mammalian and avian species are not strict insectivores or herbivores and instead consume both plant and animal matter usually depending upon the availability of food resources. For risk assessment purposes for evaluating contaminant exposures, mammals and birds are classified into these general groups based on their primary food types. Otherwise most animals would be classified as omnivores.

- *Carnivorous Wildlife* – Carnivorous mammals and birds consume primarily other mammals and birds. Carnivores are important in the control of rodents and other small mammals with high reproductive capacities.

- *Aquatic Invertivores* – Aquatic invertivores are mammals and birds that consume primarily aquatic invertebrates. These organisms are important in the nutrient processing and energy transfer between the aquatic and terrestrial environments. Some avian and bat species consume primarily emerging insects and are important in the control of these populations.

- *Piscivores* – Piscivorous mammals and birds consume primarily fish. These organisms are important in the nutrient processing and energy transfer between the aquatic and terrestrial environments.

3.1.4 Exposure Pathways of Chief Concern

Fish

The primary exposure pathway for fish is direct contact with contaminants in surface water. This is applicable to both asbestos and non-asbestos contaminants. Fish may also be exposed to contaminants by ingestion of contaminated prey items, and incidental ingestion of sediment while feeding. Direct contact with sediment may also occur. This is often assumed to be minor compared to the pathways above.

Benthic Invertebrates

Benthic invertebrates may be exposed to contaminants in surface water and/or sediment via ingestion and/or direct contact. Benthic invertebrates may also be exposed to contaminants via ingestion of aquatic prey items that have accumulated contaminants in their tissues. This is applicable to both asbestos and non-asbestos contaminants.

Terrestrial Plants and Soil Invertebrates

Terrestrial plants and soil-dwelling invertebrates (e.g., worms) are exposed mainly by direct contact with contaminants in soil. Exposure of plants may also occur due to deposition of contaminated dust on foliar (leaf) surfaces, but this pathway is generally believed to be small compared to root exposure for non-asbestos contaminants.

Mammals and Birds

Mammals and birds may be exposed to asbestos and non-asbestos contaminants via ingestion of soils, surface water, sediment and food. Mammals and birds may also be exposed to asbestos by inhalation exposures when feeding or foraging activities result in the disturbance of asbestos-contaminated soils, sediments or other media. Direct contact (i.e., dermal exposure) of birds and mammals to soils may occur in some cases, but these exposures are usually considered to be minor in comparison to exposures from ingestion (EPA, 2003). Likewise, inhalation exposure to non-asbestos contaminants in airborne dusts is possible for all birds and mammals, but this pathway is generally considered to be minor compared to ingestion pathways (EPA, 2003).

Amphibians

Amphibians (frogs, toads) inhabit both aquatic and terrestrial (mainly riparian) environments with early life stages being primarily aquatic and latter life stages primarily terrestrial. Amphibians in their early aquatic life stages may be exposed to contaminants in surface water via ingestion and direct contact. They may also be exposed to contaminants in sediment via ingestion and direct contact and to contaminants in aquatic prey items via ingestion. In the terrestrial (riparian) environment, amphibians may be exposed to contaminants in soils or sediments via ingestion, inhalation and/or direct contact and also as the result of ingestion of terrestrial prey items.

3.2 Management Goals and Assessment Techniques

3.2.1 Management Goals

Management goals are descriptions of the basic objectives which the risk manager wishes to achieve. The overall management goal identified for ecological health at the Libby OU3 site for non-asbestos contamination is:

> Ensure adequate protection of ecological receptors within the Libby OU3 Site from the adverse effects of exposures to mining-related releases of asbestos and other chemical contaminants to the environment. "Adequate protection" is generally defined as the reduction of risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota (EPA, 1999).

In order to provide greater specificity regarding the general management goals and to identify specific measurable ecological values to be protected, the following list of sub-goals was derived:

- Ensure adequate protection of the aquatic communities in Rainy Creek, Fleetwood Creek, the Tailings Impoundment, the Mill Pond, the Carney Creek Pond, and Carney Creek from the adverse effects of asbestos and other site-related contaminants in surface water and sediment.

- Ensure adequate protection of terrestrial plant and soil invertebrate communities within the mined area from the adverse effects of asbestos and other site-related contaminants in soils.

- Ensure adequate protection of the mammalian and avian assessment populations from adverse effects non asbestos contaminants in the mined area and the site drainages, and from the adverse effects of asbestos in the mined area, the site-related drainages and the surrounding forest area.

- Ensure adequate protection of the amphibian assessment population from adverse effects asbestos and non asbestos contaminants in the mined area and the site drainages, and the surrounding forest area.

3.2.2 Definition of Population

A "population" can be defined in multiple ways. A common definition of the biological population by ecologists is: "A group of plants, animals and other organisms, all of the same species, that live together and reproduce. Individual organisms must be sufficiently close geographically to reproduce. Sub-populations are parts of a population among which gene flow is restricted, but within which all individuals have some chance of mating any other individual" (Menzie et al., 2008). Population" can also be defined differently in the context of a management goal. To prevent miscommunication in risk assessment and risk management, use of the term "assessment population" is recommended (EPA 2003). In problem formulation it is necessary to explicitly state the assessment population(s). The assessment population may be the same as the biological population as defined by ecologists or may be: 1) a component of the biological population (e.g., exposed population); or, 2) a component of relevant meta-population (e.g., a subpopulation).

For the Libby OU3 Site, the assessment populations are defined as the groups of organisms that reside in locations that have been impacted by mining-related releases. For exposure to non-asbestos contaminants, this is believed to be restricted to the mined area and the drainages associated with the mined area. For asbestos, the impacted area may also include surrounding forest lands that were impacted by airborne releases of asbestos. The size of the impacted area is determined empirically based on the spatial pattern of asbestos contamination in forest soils, duff, and tree bark.

3.2.3 Assessment Endpoints

Assessment endpoints are explicit statements of the characteristics of the ecological system that are to be protected. Because the risk management goals are formulated in terms of the protection of populations and communities of ecological receptors, the assessment endpoints selected for use in this problem formulation focus on endpoints that are directly related to the management goals. This includes:

- Mortality
- Growth
- Reproduction

Other assessment endpoints may be appropriate, if it is believed that the endpoint can be related to the management goals. For example, carcinogenicity might be of concern if it could influence the reproductive potential of a species over its lifetime.

3.2.4 Measures of Effect

Measurement of effect are quantifiable ecological characteristics that can be measured, interpreted, and related to the valued ecological components chosen as the assessment endpoints (EPA 1992, 1997, 1998).

There are a number of different techniques available to ecological risk assessors for measuring the impact of site releases on assessment endpoints and assessing whether or not risk management goals are achieved. The strategies that are available for use at this site are discussed below.

1. <u>The Hazard Quotient (HQ) Approach</u>

A Hazard Quotient (HQ) is the ratio of the estimated exposure of a receptor to a "benchmark" that is believed to be without significant risk of unacceptable adverse effect:

HQ = Exposure / Benchmark

Exposure may be expressed in a variety of ways, including:

- Concentration of a contaminant in an environmental medium (water, sediment, diet and soil)
- Concentration of a contaminant in tissue
- Amount of a contaminant that is ingested by a receptor

In all cases, the exposure and benchmark must be expressed in like units. For example, exposure in surface water (mg/L) must be compared to a benchmark in mg/L. If the value of an HQ is less than 1E+00, risk of unacceptable adverse effects in the exposed individual is judged to be acceptable. If the HQ exceeds 1E+00, the risk of adverse effect in the exposed individual is of potential concern.

However, not all HQ values are equally reliable as predictors of effect. Interpretation of the ecological consequences of HQ values that exceed 1.0 depends on the species being evaluated and on the toxicological endpoint underlying the toxicity benchmark. In most cases, the benchmark values used to compute HQ values are not based on site-specific toxicity data, and do not account for site-specific factors that may either increase or decrease the toxicity of the site-related contaminants compared to what is observed in the laboratory. In addition, benchmark values are often not available for the species of feeding guild of concern, so values are extrapolated from other similar types of receptors. Consequently, most HQ values should be interpreted as estimates rather than precise predictions.

2. Site-Specific Toxicity Tests (SSTT)

Site-specific toxicity tests measure the response of receptors that are exposed to site media. This may be done either in the field or in the laboratory using media collected from the site. The chief advantage of this approach is that site-specific conditions which can influence toxicity are usually accounted for, and that the cumulative effects of all contaminants in the medium are evaluated simultaneously. One potential limitation of this approach is that, if toxic effects are observed to occur when test organisms are exposed to site media, it may not be possible to specify which contaminant or combination of contaminants is responsible for the effect without further testing or evaluation. A second limitation is that it may be difficult to perform tests on site samples that reflect the full range of environmental conditions which may occur in the field across time and space.

3. Population and Community Demographic Observations (PCDO)

Another approach for evaluating possible adverse effects of environmental contamination on ecological receptors is to make direct observations on the receptors in the field, seeking to determine whether any receptor population has unusual numbers of individuals (either lower or higher than expected), or whether the diversity (number of different species) of a particular category of receptors (e.g., plants, benthic organisms, birds) is different than expected. The chief advantage of this approach is that direct observation of community status does not require making the numerous assumptions and estimates needed in the HQ approach. However, there are also a number of important limitations to this approach. The most important of these is that both the abundance and diversity depend on many site-specific factors (habitat suitability, availability of food, predator pressure, natural population cycles, meteorological conditions, etc.), and it is often difficult to know what the expected (non-impacted) abundance and diversity should be in a particular area. This problem is generally approached by seeking an appropriate "reference area" (either the site itself before the impact occurred, or some similar site that has not been impacted), and comparing the observed abundance and diversity in the reference area to that for the site. However, it is important to locate reference areas that are a good match for important habitat characteristics. This allows comparisons that can be used to establish firm cause-and-effect conclusions between the environmental contaminat(s) and the effect on the receptor population.

4. *In-Situ* Measures of Exposure and Effects (IMEE)

An additional approach for evaluating the possible adverse effects of environmental contamination on ecological receptors is to make direct observations on receptors in the field, seeking to identify if individuals have higher exposure (tissue) levels, observed lesions and/or deformities that are higher than expected. This method has the advantage of integrating most (if not all) factors that influence the bioavailability of contaminants in the field. The limitations of this method may be in the interpretation of the consequences of the measured exposure or effect (if suitable toxicity information are not available) and if an appropriate reference population for comparison is available.

As noted, each of these alternative strategies for characterizing ecological risks has some advantages and some limitations. Because of this, it is usually desirable to obtain information using two or more alternative strategies, and to seek to reach a weight of evidence conclusions that considers the strengths and limitations of each available line of evidence. However, the choice of which one or more of these basic approaches is needed or useful in the assessment process may vary between receptors groups and contaminant types. Section 4 presents the sequence of assessment steps that were used to evaluate risks to ecological receptors from LA, and Section 5 describes the strategy that was used to evaluated ecological risks from other (non-asbestos) contaminants.

4.0 ASSESSMENT OF ECOLOGICAL RISKS FROM ASBESTOS

As noted above (see Section 3.2), there are several alternative lines of evidence that may be investigated in order to characterize the risks to ecological receptors from site-related contaminants. In many cases, the first line of evidence investigated is the HQ-approach. However, in the case of asbestos, no toxicity reference values (TRVs) have been derived to date for any receptor class, and most of the studies that are available that might potentially serve as a basis for a TRV are based on studies of chrysotile asbestos rather than amphibole asbestos. In particular, there are no studies on the toxicity of LA on any class of ecological receptors. Because of this, an HQ-based approach can not be implemented for a receptor group unless a toxicity study is performed that is adequate to define a reliable TRV. In the absence of a reliable TRV, the strategy for assessing risks from asbestos must be based on information that can be collected from field studies of the following types:

- Site-specific toxicity testing
- Site-specific population surveys
- Site-specific studies of biomarkers of exposure and effect

4.1 Risks to Fish

Adverse effects of exposure of fish to asbestos have been reported in several studies. Belanger et al. (1985, 1990) found that surface water concentrations of chrysotile asbestos as low as 0.01 million fibers per liter (MFL) significantly affected the reproduction of Japanese Medaka (*Oryzias latipes*) exposed over chronic durations. Behavioral effects were noted in coho salmon (*Oncohynchus kisutch*), green sunfish (*Lepomis cyanellus*) and fathead minnows (*Pimephales promelas*) from surface water exposure of about1 MFL chrysotile asbestos (Belanger et al. 1985, 1986). Other studies (Woodhead et al. 1983, Batterman and Cook 1981) demonstrate the accumulation of asbestos fibers in tissues of fish exposed to asbestos in water. However, as noted above, no studies were located on the toxicity of LA to fish.

4.1.1 <u>HQ Approach</u>

4.1.1.1 TRV for LA in Water

Because the toxicity of asbestos is likely to depend on the form of asbestos, none of the studies summarized above were considered to be good candidates for the derivation of a TRV for LA. Consequently, a study was designed and implemented as part of the Phase III RI for OU3 to characterize the effects of LA exposure on rainbow trout fry.

Study Design

The design of this toxicity study was complicated by two key issues, as discussed below.

Issue 1: Form of LA in Site Water

Examination of site waters indicates that LA may occur in both a free form, and as "clumps" in which multiple LA fibers exist bound to an organic material (add citation). This was first recognized by TEM analyses of site waters in which occasional clumps of LA were observed on the filters. The presence of clumps in site waters was further demonstrated by noting that treatment of site waters with ozone in accord with EPA Method 100.1 tended to increase the apparent concentration by several fold:

Show data here in a table

Assuming that clumped fibers might not have the same toxicity as free fibers, the traditional approach for dealing with such a 2-phase system would be to measure individual TRVs for both free fibers and clumped fibers, measure the concentration of both free and clumped fibers in site water, and computing the risk as follows:

HQ(free) = C(free)/TRV(free)
HQ(clumped) = C(clumped)/TRV(clumped)

If the mechanism of toxicity were the same for free and clumped fibers, then the total HQ would be calculated as the sum:

HQ(total) = HQ(free) + HQ(clumped).

If the mechanism of toxicity were different, then the HQ values would not be added.

The Biological technical Assistance Group (BTAG) and/or sub-groups of the BTAG for OU3 met several times to discuss the best approach for measuring free and clumped fibers in water, and for designing the toxicity study. After debate, the BTAG indicated general agreement that an assessment of the toxicity of free fibers could be performed by using LA-spiked laboratory water (as opposed to site water), taking care to ensure that fiber clumping did not occur during the study, and that the toxicity of site waters could be estimated by measuring the total concentration of LA (free plus clumped) in site waters, and applying the TRV for free fibers to the total LA concentration:

HQ(total) ≈ C(total)/TRV(free)

It was agreed that this approach, which assumes that clumped LA is equitoxic with free LA, was uncertain, but that the uncertainty was likely to be within a range that is acceptable for risk management decision making at Libby OU3.

Issue 2: Potential Changes in Fiber Form During Laboratory Tests

The second factor that complicated the design of the fish toxicity test was the finding that LA in non-sterile water tends to undergo clumping and binding to the walls of containment vessels (EPA 1983). Such time-dependent binding and clumping of LA in water was observed in a site-specific toxicity test that was performed as part of Phase II of the OU3 RI (see Section 4.1.2, below). If uncontrolled, this time-dependent tendency to clump and bind would make it very difficult to control the level and form of LA to which the fish were exposed, and it would be very difficult to interpret the results of such a study.

In order to address this problem, [insert here on study design, plus results of pilot studies]

Results

Insert on results of fish tox test and identification of TRV

4.1.1.2 Concentration Values of LA in Site Water

INSERT

4.1.1.3 HQ values for LA in Site Water

INSERT

4.1.2 <u>Site-Specific Toxicity Tests</u>

During Phase II of the Remedial Investigation (RI) for the Libby Superfund Site Operable Unit 3 (OU3), a laboratory toxicity test was conducted in which rainbow trout (*Oncorhynchus mykiss*) were exposed to site water collected from Libby OU3.

The water sample used for testing was collected from the tailings impoundment in OU3 on May 8, 2008. Triplicate analysis of LA in this sample (measured before the toxicity test began) showed that the concentration was about 21 ± 6 million LA fibers per liter (MFL).

The toxicity test design is detailed in the Phase IIA SAP (EPA 2008a). The test was conducted with newly hatched larval (sac fry) rainbow trout (*Oncorhynchus mykiss*) under static renewal conditions for an exposure duration of 6 weeks. Six concentrations of LA were tested on the fish, plus a control (0 MFL). Nominal concentrations between 0.3 and 30 MFL were generated by adding the appropriate amount of site surface water to sterile water. During the test, the water was renewed every ten days during the sac-fry exposure (days 0-20) and every three days following swim-up of the organisms (days 20-42). A new cycle began each time the water was renewed. Survival, behavior and growth were observed during the exposure period. At the end of the test the histopathology of the fish were examined.

Results from this showed no significant effect on any endpoint when compared to controls (give citation). However, analysis of water samples taken from the test aquaria during the study revealed that, after several days of exposure, asbestos concentrations were significantly lower than planned (see Table 3-1). Further investigations indicated that the most likely reason for the low concentrations was that LA in the water tended to become clumped with organic material, and that a substantial fraction of the LA became bound to the walls of the aquaria and/or the stock bottle. Based on this, EPA concluded that the magnitude and duration of exposure of the fish to LA in the toxicity tests could not be reliably estimated, and that the results of this study could not be used to draw reliable conclusions about risks to fish exposed to LA in site waters.

Because of the tendency for clumping and binding of LA in site waters, no further attempt at site specific toxicity testing of surface water from OU3 was pursued.

4.1.3 Population Studies

Study Locations

Fish population studies were performed at several stations in upper and lower Rainy Creek in October of 2008 and September of 2009 . Fish population studies were also performed at two reference locations, including a tributary to Bobtail Creek (BTT-R1) and Noisy Creek (NSY-R1). These two reference stream locations were selected by EPA with assistance from the USFWS after an extensive reconnaissance of local steams that considered a number of potentially relevant habitat factors, including general appearance, elevation, aspect, gradient, flow, and proximity to an impoundment. The locations of the stations selected for fish population surveys are shown in Figures 3-1 and 3-2.

Study Methods

Fish were collected at each station following the removal method using electroshocking equipment. Nets were established at the head and tail of each station (usually about xx meters long) to prevent fish from escaping, and two or three electroshocking passes were made at each location. Because electroshocking does not always result in efficient capture of small fish (<66 mm), studies performed in 2009 also used minnow traps placed in the test reaches before electroshocking began to provide additional data on the occurrence of smaller fish. Length, weight, species type, and a description of external abnormalities or moralities were recorded for each fish collected.

Raw Data

Table x-x summarizes the results of the fish surveys performed in 2008 and 2009. [need one or more tables that show fish count stratified by year, station, species, size and method] Inspection of these data yields the following main conclusions:

- The number of fish caught by electroshocking was higher in 2009 than 2008. These differences are thought to be a result of normal between-year variability as well as variability inherent in the sampling method used.
- Species composition varied considerably between locations. Rainbow trout were the most abundant species caught at LRC; cutthroat and hybrids were most abundant at URC; brook trout and rainbows were the most abundant at BTT; and hybrids were most abundant at NSY.
- YOY appear to be absent from most of LRC.

Estimation of Population Density

There are several alternative methods available for estimating the number of fish present in a reach using the electro-shocking data.

MLE Method

One method assumes that the capture efficiency of fish is constant across multiple passes, and fits the data from 2 or more passes to a falling exponential equation:

$$C_i = N_{i-1} \cdot p$$

where:

Ci = Number of fish captured in pass "i"
N_i = Number of fish present before pass "i" is performed
p = probability of capturing a fish during a electroshocking pass

The value of p is estimated from the data equation using the method of maximum likelihood estimation (MLE).

Although this method is commonly used, there are several potential limitations. First, the method assumes that p is a constant between passes, which may not be true (Peterson et al. 2004). In addition, this method assumes that all electroshocking passes were performed on the same day, and that the same number of passes were performed at stations being compared. Also note that this method does not yield reliable results when a higher number of fish is caught in later passes than in earlier passes.

One Pass Method

A second method for estimating initial population density utilizes only the data from the first pass, and assumes a species-specific and size-specific capture efficiency that is based on observations at other similar sites:

$$N_0 = C_1 / p_1$$

where:

N_0 = number of fish present in the reach before electroshocking
C_1 = number of fish captured in electroshock pass 1
p_1 = predicted capture efficiency in the first pass

The capture efficiency of trout (per first electroshocking pass) was estimated from measures of wetted stream cross-sectional area using CapPost software (Peterson and Zhu 2004). Predicted capture efficiency was calculated as:

$$p_1 = 1/\{1+\exp(-b0 + b1 \cdot x1 + b2 \cdot x2 + \ldots)\}$$

where:

p_1 is the predicted capture efficiency in pass 1
b0, b1, etc. are model coefficients
x1, x2, etc. are the corresponding variable values

Capture efficiencies were estimated to be between 17% and 36% for rainbow and cutthroat trout, depending on location and size group (Table 3-2). Capture efficiencies could not be estimated specifically for brook trout at this time because the method requires input of the percentage of undercut banks (to estimate brook trout capture efficiency only), so it was assumed for the purposes of this evaluation that capture efficiencies of brook trout were similar to rainbow and cutthroat trout.

Because both of these methods have potential advantages and limitations, population estimates were derived using both approaches. Results are shown in Table 3-2. Inspection of the data yields the following conclusions:

- Capture efficiencies were low (30-40%) and were similar across locations and years for the two larger size classes and very low (16-18%) for the 60-99mm size class.

- Estimated population abundance from both years of data was approximately 145% less in LRC compared to BTT.
- Estimated population abundance was lower in 2008 at URC compared to NSY, but there were essentially no differences between these streams in 2009.

Density and Biomass

Fish density and fish biomass per acre were calculated from first pass data (Figures 3-6 and 3-7). Inspection of the data yields the following conclusions:

- Total fish densities are lower in LRC compared to BTT.
- Total fish densities are lower in URC in 2008 compared to NSY, but in 2009, URC-2 density was twice the density at NSY.
- Total fish biomass values are the same or greater in LRC and lower in URC than the respective reference streams BTT and NSY.
- Individual species density or biomass differences are not comparable between Rainy Creek stations and reference streams because the species composition varied considerably between streams.

Coefficient of Condition

Fish length and weights from first pass data were used to compute a Coefficient of Condition (COC). COC is a measure of fish robustness, where increasing COC indicates increased relative robustness or well-being of the fish (Williams 2000). COC is calculated as:

$$COC = W \cdot 100 / L^3$$

where:

W = weight (g)
L = Length (mm) [CHECK UNITS]

Results are shown in Table 3-3. Inspection of the data [no stats??] indicates that COC does not vary substantially between stations.

Characterization of Population Demographics

The fish population metrics (abundance, density, and size class differences) from the 2008 and 2009 data show there are lower populations of fish in LRC compared to both the LRC reference creek, BTT, and the other locations evaluated. Absolute measures of metrics tended to be higher in 2009 than in 2008, either due to differences in sampling methods or natural temporal variability in fish populations, but the patterns of most demographic parameters remained consistent between years. In both years, fish abundance and density per acre were lower in LRC compared to BTT, and YOY (defined as fish smaller than 66 mm) were consistently absent from LRC during both years of collection (except for TP-TOE in 2009, for which YOY were present). The condition of the fish in LRC compared to BTT does not appear to be different. Biomass and COC was approximately the same between locations.

Of note is that the predominant fish species in BTT is brook trout, whereas species present in other locations include rainbow, cutthroat or a hybrid of these species. Brook trout are more territorial than rainbow or cutthroat, which could result in a lower expected density and abundance per acre than sites with rainbow or cutthroat, and biomass and COC may not be directly comparable. However, even with a reference stream containing predominantly brook trout, which would reduce estimates of density and abundance, results still show higher numbers of fish in this stream compared to LRC, and hence the overall conclusion that fish populations are lower in LRC is still valid.

Differences in fish populations between URC and its reference site, NSY, were also apparent but were less consistent. Population abundance and density was lower in 2008 in URC compared to NSY, but not in 2009. However, it should be noted that the mean wetted cross-sectional areas at URC locations were small, especially at URC-1A in 2008, and lower than the range of data (0.2 – 2.35 m^2) used to develop the model. Thus, estimates should be interpreted with caution for URC. Overall biomass estimates were lower in URC compared to NSY during both years. YOY were present at both locations in URC and total numbers were higher than for NSY in 2009.

Potential Causes of Population Differences

Currently, causal factors for the lower fish populations in LRC, and possibly URC, cannot be distinguished. Habitat factors, asbestos or other chemicals may all influence population differences.

Stream and habitat information were collected during fish sampling. Basic stream characteristics were measured as shown in Table 3-4. Several habitat parameters were collected in 2008 via visual observation and are considered to be qualitative (Tables 3-5 and 3-6). In 2009, a few additional parameters were measured quantitatively via the pebble count method (substrate composition, embeddedness) or by a densitometer (overhead riparian cover). Descriptions of barriers along LRC were also made in 2009.

Some of these habitat quality parameters suggest that the conditions in Rainy Creek, especially LRC, may be different from reference streams:

1) Of the quantitative habitat data collected in 2009, all Rainy Creek locations had a greater density of overhead riparian cover than the two reference areas. Substrate composition in LRC included a greater percentage of silts and clays and higher

embeddedness scores, compared to BTT. These differences may have limit spawning sites in LRC.

2) Of the qualitative data that were collected, visual observations of woody debris, which provides important coverage for YOY, suggest there might be less coverage in LRC compared to other locations. Additionally, the barrier assessment that was conducted in 2009 indicates that the barriers in LRC are large enough to prevent fish recruitment (although not assessed, barriers in URC also presumably prevent fish recruitment) and that stream locations in the LRC sites do not have high quality habitat for YOY and do not provide enough pools and undercut banks for cover. However no formal assessment was made of these parameters.

3) A comparison of stream characteristics among locations within the same year shows that turbidity and conductivity values are consistently higher in URC compared to NSY. Lower stream velocity and slightly higher conductivity values (~100 umhos/cm increase) were also noted for LRC compared to BTT, but other parameters were not notably different. Interpretation of between-year comparisons of the different parameters were not made as differences were assumed to be a function of different sampling times, weather conditions, and the natural temporal variability of the streams.

4.1.4 In Situ Effects

In situ effects analysis consisted of direct observations of visible abnormalities, deformities and mortalities of fish as they were collected from the field by the electroshocking method. A summary of the data is shown in Table 3-7. Frequency of observed abnormalities was approximately similar between all locations. All abnormalities noted in the field (consisting of gill flaring, burn marks, discolorations, hemorrhages and spinal deformities) were expected to result from the effects of electroshocking and capture of trout (Parametrix 2010).

The frequency of mortalities observed in fish collected at UCR-2 was greater than the reference area or any other stream location. There is a wide variation in susceptibility to electroshock-induced mortality among species (Henry et al. 2004), but juveniles appear to be particularly susceptible to adverse effects (Habera et al. 1996, Wahl et al. 2007) and most mortalities at UCR-2 were associated with the smaller fish at this location. Therefore, the in situ effects observed in sampled fish appear to be the result of the sampling method used to obtain the fish rather than any site-related effect.

4.1.5 Weight of Evidence Evaluation

Three lines of evidence are available to evaluate potential risks to fish in Rainy Creek, including:

Poor Quality Source Document

The following document images have been scanned from the best available source copy.

To view the actual hard copy, contact the Region VIII Records Center at (303) 312-6473.

- Hazard quotients
- Population studies
- In situ effects

The strength of each line of evidence is discussed below.

HQ values based on a TRV for free LA fibers compared to measure of total LA in site water indicate ....INSERT

Fish populations studies are the most complete line of evidence investigated. These studies show that fish populations are lower in LRC than in URC and in two other reference locations. An evaluation of habitat data suggests that difference in habitat might be contributing to the observed differences in population, but the differences in habitat are not sufficiently large to suggest that habitat is the only cause of the difference.

Absence of external signs of abnormality are consistent with the hypothesis that asbestos is causing no effects, but the data are not powerful because absence of external lesions does not indicate the absence of internal lesions.

Final WOE paragraph ....

4.2 Risks to Benthic Invertebrates

Several studies indicate that exposure to asbestos may have adverse effects on aquatic invertebrates. Belanger et al (1986) evaluated the effects of chrysotile exposure on Asiatic clams exposed via water and reported adverse impacts related to behavior, growth and fiber accumulation. Stewart and Schurr (1980) investigated the effects of chrysotile and amphibole (crocidolite) exposure on mortality of brine shrimp. Although the crocidolite showed no significant effect compared to chrysotile [what about control??], the authors noted that the crocidolite "did not mix in the water", suggesting the findings may not be reliable.

4.2.1 HQ Approach

TRVs have not been derived to date for benthic macroinvertebrates for LA asbestos, or any other form of asbestos. Consequently, it is not currently possible to use the HQ-based method as part of the benthic invertebrate assessment strategy for asbestos.

4.2.2 Site-Specific Toxicity Tests

In 2008, site-specific sediment toxicity tests were conducted for two benthic macroinvertebrates, a freshwater amphipod (*Hyalella azteca*) and a midge (*Chironomus tentans*) (Parametrix 2009 a,b). The toxicity testing was conducted at the Parametrix Environmental Research Laboratory (PERL) in Albany, OR.

Sediments for testing were collected from two locations in OU3. This included a station near the headwaters of Carney Creek (CC-1) (need to add this location to Figure 3-2) and a location immediately downstream of the tailings impoundment (TP-TOE2), as shown in Figure 3-2. LA concentrations in these sediment were measured using polarized light microscopy (PLM). The resulting concentration estimates were 5% and 3% in the CC-1 and TP-TOE2 sediments, respectively.

Sediments from two site-specific reference locations were also tested, including a tributary to Bobtail Creek (BTT-R1) and Noisy Creek (NSY-R1). These two reference stream locations were selected by EPA with assistance from the USFWS after an extensive, on the ground, search of the area. Attributes considered in selecting reference streams to compare to Rainy Creek included elevation and visual observations of depth and width, length, substrate, orientation, overall habitat similarity and access. Figure 3-3 illustrates the location of these two reference locations. Analysis of these two sediments by PLM did not reveal any detectable LA.

Organisms were also exposed to two laboratory formulated control sediments and one field collected control sediment from an uncontaminated location in Oregon.

Results for Chironomus tentans

C. tentans were exposed to site or control sediments for 52 days using a static renewal study design (USEPA 2008). Effects on survival were assessed at Day 24 and Day 52, while effects on growth and reproduction were assessed on Day 52.

Table 3-8 presents the results. Toxicity test results are somewhat mixed due to the high Day 24 survival rate and the increased number of eggs in the egg cases on Day 52 compared to the reference locations. If survival at Day 52 and percent hatchability are considered to be more important than the number of eggs, then the OU3 stations are uniformly negative compared to the reference areas, with percent emergence and growth both more than 20% lower than the reference locations.

Results for Hyalella azteca

H. azteca were exposed to site or reference sediments for 42 days (USEPA 2008).

Table 3-9 presents the results. Toxicity test results do not indicate any significant impacts from OU3 sediment compared to reference areas. Percent survival is slightly decreased, however, growth and reproduction measures are both elevated compared to reference areas.

As part of the study using *H. azteca*, samples of "pore water" were collected from the sediment chambers before and after toxicity testing. The purpose of this was to determine if there was any substantial change in the concentration values during the test. Results are shown below:

Sediment	LA Concentration in Porewater (BFL)	
	Initial	Final
CC-1	18.7	2.9
TP-TOE2	25.4	2.8
NSY-R1	ND	ND

BFL = billion fibers per liter

As seen, there was a an apparent decrease in the concentration of LA in porewater between the start and end of the test. The basis of this apparent decrease is not known, but might be mediated by binding and clumping of LA fibers to organic (bacterial) matter, similar to what was observed in the initial site-specific toxicity test with fish (see Section xxx). However, the significance (if any) of this change is difficult to assess. For most other contaminants in sediments, it is generally believed that toxicity is mediated mainly via dissolved chemical in the porewater (add reference; prothro). However, for asbestos, it is unknown whether sediment toxicity to benthic organisms is mediated mainly by direct contact with free fibers, by contact with fibers bound to sediment particles, or even by ingestion of fibers. Thus, it is not known whether this apparent change in the state of LA fibers during the study might tend to increase, decrease, or have no effect on benthic toxicity.

4.2.3 Population Studies

During the 2008 and 2009 field seasons, benthic invertebrate population surveys and habitat assessments were performed at two stations on upper Rainy Creel and five stations on lower Rainy Creek (add citations for study design and for results report). The Rainy Creek sampling locations are illustrated in Figure 3-2. Population studies were also performed at the Noisy Creek (NSY-R1) and Bobtail Creek tributary (BTT-R1) reference stations (Figure 3-3).

Based on a consideration of elevation and other features, the Noisy Creek station (NSY-R1) is considered to be the most appropriate reference for comparison to upper rainy Creek stations (URC 1A and 2), and Bobtail Creek tributary (BTT-R1) is the most appropriate reference for comparison to the five lower rainy Creek sampling locations.

Sampling Methods

Macroinvertebrate population data were collected in 2008 and 2009 using two different methods, a kick-net method and a Surber sampler method, both of which are described in SOP# BMI-LIBBY-OU3 (Rev.0).

The kick-net method follows EPA's current RBP protocol (Barbour et al. 1999). This method is a semi-quantitative sampling technique designed to collect a representative macroinvertebrate sample in second to fifth order streams in riffle and various other habitats along a single meander length of a low-gradient stream (Barbour et al. 1999). Benthic invertebrates are collected systematically from all available in-stream habitats by kicking the substrate or jabbing with a D-frame dip net. A total of 20 jabs (or kicks) are taken from all major habitat types in the reach, resulting in sampling approximately 3.1 m^2 of habitat. Major habitat types included riffles, runs, woody debris and undercut banks. All samples in riffles and runs were collected by disturbing the substrate (kicks), while in woody debris and undercut banks, samples were collected by using multiple jabs. Because of the relatively large area sampled, the kick-net approach tends to minimize potential issues associated with small-scale variability in benthic density and diversity at a station.

The Surber method collects benthic macroinvertebrate community data using a 0.279 m^2 sampler frame with a 250 μm mesh net. Samples are collected by disturbing the area within the square sampling frame by hand and scrubbing individual woody debris and cobbles within the square sampling area for a total of 90 seconds, then allowing the invertebrates and detritus to wash downstream into the net. Three samples were collected and composited to form a single sample with a total area of 0.837 m^2 per sample. While more quantitative that the kick net method, because of the relatively small area sampled, the Surber method may be influenced by small-scale variability in benthic organism density.

Data Analysis

For both sampling methods, a sample of benthic organisms (usually 100, 200, 300, or 500 organisms) [which did we use here?] was sorted in the laboratory and identified to the lowest practical taxon (generally genus or species). Based on the count of organisms by taxon, 38 alternative macroinvertebrate metrices were calculated. Metric categories include taxonomic density and diversity, community composition, pollution tolerance, trophic behavior (functional), and feeding mechanisms (habit). These metrices are presented in [where are the data?]

The rationale for selecting, combining and evaluating these metrics is dependent on many factors, including stream location and project goals. EPA's current RBP guidance for streams and rivers emphasizes the need for establishing both regional and site-specific reference conditions, and the need for more localized metric selection, calibration and aggregation into indices (Barbour et al. 1999).

These metrices were then combined to form a multi-metric index (MMI) for each station. An MMI provides a means of integrating information from a group of metrics selected for their site-specific robustness in discriminating between reference and stressed conditions for the specific region and local ecosystem. The establishment and use of a more localized MMI increases the credibility of the MMI results used for decision making (Barbour et al. 1999). In addition, regional and local knowledge can sometimes allow for weighting the value of each metric in a manner appropriate for regional conditions, i.e., recognizing that some metrics may be more important in some locations.

The Montana DEQ (MDEQ) has spent considerable time and effort to develop Montana-specific reference areas and calibrate associated MMIs (Jessup et al. 2006, MDEQ 2006). In considering regional-specific locations, MDEQ screened all of the RBP metrics for their regional-specific discrimination efficiency, i.e., their capacity to correctly detect stressed conditions. MDEQ also considered metric variability, ecological meaningfulness and metric redundancy and, ultimately, created three Montana-specific MMIs for mountains, low valleys and plains. The Mountain MMI is appropriate for the Libby Mine site and is used to evaluate the macroinvertebrate population and demographic data.

Montana's Mountain MMI uses seven metrics, each with a weighted scoring method, as shown in Table 3-10. The Mountain MMI is calculated by averaging the seven metric scores. Macroinvertebrate community impairment is considered unimpaired if the overall score is greater than 63, moderately impaired with a score from 29-62 and severely impaired if the score is less than 29.

Figure 3-10 shows the absolute MMI scores based on benthic macroinvertebrate data collected using the kick-net method for 2008 and 2009. As seen, the scores are relatively consistent between 2008 and 2009. Scores for the URC sites and Noisy Creek suggest non-impaired macroinvertebrate populations. For LRC, most of the sampling locations show some impairment. However, only TP-TOE2, LRC-1 and LRC-2 show consistent impairment below the reference area. What about BTT??

MDEQ Mountain MMI scores based on the Surber data are shown in Figure 3-xx. As seen, the results [what?]. The reason for this variability is not certain, but may be attributable to the smaller area and fewer habitats sampled using the Surber method. Therefore, these data are not used further for evaluating benthic macroinvertebrates.

Habitat Quality

Although reference stations were selected in order to obtain a good match in key habitat factors, a perfect habitat match between site and reference locations is never possible. Therefore, it is generally helpful to perform a quantitative habitat assessment at each station where population metrices were collected in order to judge whether ay apparent differences in population metrics might be explained in terms if habitat differences.

To this end, habitat quality data were collected in 2008 and 2009 according to methods described in EPA's current RBP protocol (Barbour et al. 1999) and referenced in Libby SOP# BMI-LIBBY-OU3 (Rev.0). These data were combined to create a single Habitat Assessment Score for each sampling location using what method and what metrices??. Results are shown in Table 3-11 and Figure 3-11.

Inspection of Table 3-11 an Figure 3-11 reveal that both reference areas and URC were generally considered to provide "optimal" habitat [where does this definition come from?] for macroinvertebrates in both 2008 and 2009. Habitat quality in URC was nearly identical to Noisy Creek, with both locations falling within the optimal range and showing little change between 2008 and 2009.

For LRC, habitat scores were more variable over time, being 8-14% lower in 2009 than 2008. Overall, the habitat quality scores at LRC locations compared to Bobtail Creek were somewhat reduced, falling into the slightly suboptimal range., whereas Bobtail Creek habitat is considered as optimal. The absolute score differences between LRC and Bobtail Creek are relatively minor, however, with LRC habitat scores ranging between 79-98% of Bobtail Creek scores. These data suggest that habitat quality should not be a significant limiting factor for macroinvertebrate populations in Rainy Creek.

Figure 3-12 illustrates the relationship between habitat quality as a percent of the reference area and the Mountain MMIs of benthic community status. As seen, the URC sites and Noisy Creek show non-impaired macroinvertebrate populations and optimal habitat. For LRC, the three downgradient stations closes to the mine, TP-TOE2, LRC-1 and LRC-2, show consistent macroinvertebrate impairment compared to the reference area, with only one of these stations, LRC-1, indicating slight habitat impairment.

<u>*4.2.4 In Situ* Effects</u>

No data were collected on the incidence of any gross or histological lesions or abnormalities in benthic organisms exposed *in situ* to LA in site sediments. [can we say that no unusual gross lesions were noted during taxonomic classifications ??]

<u>4.2.5 Weight of Evidence Evaluation</u>

Two assessment methods were considered to evaluate the potential impacts of LA on aquatic macroinvertebrates:

- Site specific toxicity testing
-
- Population surveys

Site-specific sediment toxicity tests with *C. tentans* and *H. azteca* showed mixed results. For *C. tentans*, there were significant impacts to percent emergence and growth compared to reference locations (>20%). For *H. azteca*, no significant impacts to any measurement endpoint were observed. However, a porewater asbestos concentration test was conducted at the beginning and end of the *H. azteca* toxicity test demonstrated an 88% drop in LA concentration between the beginning and end of the test. Because benthic invertebrates spend most of their time in the porewater, it is unclear whether significant exposure actually occurred. Thus, this line of evidence suggests possible impacts but is not strong.

Benthic macroinvertebrate population studies do show that the three downgradient stations closest to the mine are impaired and that habitat is not likely an explanation for that impairment. This line of evidence is the strongest and the least ambiguous of the four assessment methods. Overall, it is likely that benthic macroinvertebrate populations immediately downstream of the mine site (TP-TOE 2, LRC 1 and 2) are impaired as a result of LA asbestos concentrations in sediment and surface water.

4.3 Risks to Amphibians

4.3.1 HQ Approach

4.3.2 Site-Specific Toxicity Tests

4.3.3 Population Studies

4.3.4 In Situ Effects

4.3.5 Weight of Evidence Evaluation

4.4 Risks to Small Mammals

4.4.1 HQ Approach

At present, TRVs have not been derived for either oral or inhalation exposure of mammals to LA asbestos, or any other form of asbestos. Consequently, it is not currently possible to use the HQ-based method as part of the benthic invertebrate assessment strategy for asbestos. Even if oral or inhalation TRVs were available, estimating HQ values would be hampered by lack of reliable quantitative data on LA exposure levels by either route. Consequently, no attempt was made as part of the OU3 RI to derive oral or inhalation TRVs for small mammals, and the HQ approach as not pursued as feasible a line of evidence.

4.4.2 Site-Specific Toxicity Tests

No site-specific toxicity tests were performed for any small mammals as part of the RI at OU3. This is because of uncertainty in what environmental media (soil, duff, food, air) constitute the chief exposure source to mammals, and the extreme technical difficulty that would attend the planning and implementation of any such study.

4.4.3 Population Studies

Site-specific populations studies for small mammals were not implemented as part of the RI for OU3. This is because population levels can vary substantially between locations and between years as a function of a wide variety of different factors. Consequently, data from many years of surveys would be required before meaningful comparisons could be drawn, and these conclusions would be subject to uncertainty stemming from differences in habitat and other factors (disease prevalence, predation rates, etc.) between site and reference locations.

4.4.4 In Situ Effects

At present, the only line of evidence available to evaluate risks to wildlife from asbestos is the direct measurement of exposure and effect in organisms collected from the site. This technique has the advantage that it allows an assessment of exposure and effects by both oral and inhalation exposures, and may allow development of maps that indicated the relative levels of exposure as a function of location. The chief disadvantage of this method is that biomarkers of exposure and effect are not easy to extrapolate to effects on growth, reproduction and survival, and hence on population stability.

Indicator Species

In order to implement this approach, it was first necessary to identify an indicator species for evaluation. The most important selection criteria include the following:

- Non-transitory. Some organisms migrate over long distances, and are present in the area of the site for only a short time each year. Because of the brief interval they would be exposed, such organisms would have less exposure than organisms that are present year round or for most of the breeding season.

- Small home range. Organisms that have a large home range are likely to spend a small part of their time in and about the most heavily impacted areas of the site. Consequently, they are likely to be less exposed than organisms that have a small home range and spend a high fraction of their time in and about the impacted areas.

In addition to these two baseline factors, there are a number of other factors that may also influence the relative level of exposure, including the following:

- Foraging strategy – Species that forage on the ground and have a greater potential to disturb asbestos fibers are expected to have more inhalation exposure than those that forage in shrubs or tree foliage. Species that feed in flight on insects and carnivores that prey on other mammals and birds are expected to be less exposed. Species that forage on aquatic organisms and fish would also be less exposed because inhalation exposures require the disturbance of fibers which is less likely under wet conditions.

- Habitats and Nesting – Where species find shelter, give birth (or nest) and/or rear young may also influence exposures. Many species burrow into the ground or create shallow runs under forest litter. Some others will create nests/dens in existing cavities of barren rock or dead trees. Burrowers are expected to receive higher exposures compared to those species that live higher in trees.

- Body Size – Ingestion rates and breathing rates per unit body weight tend to be higher for species with small body weights compared to species with higher body weights. Thus, exposure by both oral and ingestion pathways may be highest for small receptors.

- Longevity In humans, it is well established that risk of adverse effects is a function of cumulative exposure. That is, risk depend both on exposure level and also on exposure duration. For this reason, organisms that have longer life spans will tend to have higher cumulative exposures and hence may be more likely to display adverse effects from asbestos exposure.

Taking these factors into account, the feeding guilds and species identified as residing within the area of Libby OU3 (listed in Attachment A) were evaluated in order to identify a list of receptors most likely to have high exposures to LA, as follows:

1) Species inhabiting terrestrial and riparian habitats were segregated into two groups based on habitat type (terrestrial and riparian).
2) Because exposures to asbestos for species inhabiting riparian habitats are expected to be primarily related to ingestion of aquatic food items as well as surface water and sediments, the riparian species were segregated into two exposure groups by feeding guild. These include aquatic invertivores/omnivores and piscivores.
3) For species that inhabit terrestrial habitats, those that forage on the ground and or inhabit nests or burrows were identified from the larger list and classified into a "ground" foraging group. These species are expected to be the highest exposed to asbestos via inhalation and ingestion as a result of probing and disturbing asbestos in soils and ground litter.

4) Species that forage primarily in trees and shrubs were identified from the larger list and classified as an "arboreal" foraging group. These species may be exposed to asbestos on tree bark or leaf surfaces as result of foraging for food.
5) Carnivorous species were identified and placed in separate group based on feeding guild. These species are expected to be exposed to asbestos primarily via ingestion and inhalation exposures are expected to be lower than those species that forage on the ground for food.
6) The ground and arboreal groups were further stratified into feeding guilds (invertivore, grainivore, omnivore, carnivore) to reflect exposures related to ingestion.
7) The species in each group were then reviewed further and those with small home ranges and small body sizes were selected preferentially. These species are expected to be maximally exposed to asbestos impacted area and will not range in and out of the area.
8) For avian species, birds that are transients (occurring at the site only during spring or fall migrations) were excluded, while birds that are resident year round or are present for extended periods during the warm weather were retained.

Measurement of Asbestos Tissue Burdens

If this approach is implemented, asbestos tissue burdens in selected organs (lungs and gastrointestinal tract) of animals collected at the site would be analyzed for asbestos tissue burden. Tissue burden in lung will be interpreted as an indication of inhalation exposure, and tissue burden in the GI tract and kidneys will be taken as an indication of oral exposure. Comparison of the data from on-site locations and reference locations would be used to establish an empiric estimate of the spatial extent where LA exposures can be recognized as being higher than background.

Histopathology

A large number of studies have been performed in mammals to identify the effects of inhalation exposure to asbestos on the respiratory tract, and, to a lesser degree, the effects of inhalation and ingestion exposure on other organs (e.g. gastrointestinal tract). In animals, histological signs of tissue injury can be detected at the site of deposited fibers within a few days (ATSDR 2001). Ingestion exposures have been associated with lesions in the parathyroid tissue, brain tissue, pituitary tissue, endothelial tissue, kidney tissue, and peritoneum tissue (Cunningham et al., 1977). Induction of aberrant crypt foci in the colon (Corpet et al., 1983) and tumors of the gastrointestinal tract have also been reported. Inhalation exposures are associated with fibrosis, lung tumors and lesions along the respiratory bronchioles, alveolar ducts, alveoli, and lung tissue (McGavran et al. 1989; Donaldson et al. 1988; Davis et al., 1980a, 1980b, 1985, 1986). Mesotheliomas have been observed (Davis and Jones 1988, Davis et al. 1985, Wagner et al. 1974, 1980, Webster et al. 1993). The histopathological effects of asbestos exposures in avian species is not known.

If this line of evidence is pursued, organisms collected from site locations (on-site, forest area, riparian area) will be examined for gross and microscopic pathological effects. The incidence and severity of effects observed will be compared to organisms from suitable reference areas, and will also be correlated with the relative concentrations of LA in the collection area. These data, combined with the tissue burden data, will help define the spatial extent of LA contamination that can impact wildlife. Interpretation of the ecological consequences of any gross or histological lesions that are observed will be based on literature information that associates the pathology effects with adverse effects on growth, reproduction, and survival, as well as on consultation with experts in the field.

Weight of Evidence Evaluation

Enter text here

4.5 Risks to Birds

4.5.1 HQ Approach

4.5.2 Site-Specific Toxicity Tests

4.5.3 Population Studies

4.5.4 In Situ Effects

4.5.5 Weight of Evidence Evaluation

4.6 Risks to Federal and State Species of Special Concern

As noted earlier (see Section 2.5.4), there are a number of State or Federal species of special concern that might occur in the vicinity of Lincoln County. This includes the following:

- Coeur d'Alene Salamander (*Plethodon idahoensis*)
- Boreal Toad, Green (also known as Western Toad) (*Bufo boreas*)
- Flammulated Owl (*Otus flammeolus*)
- Northern Goshawk (*Accipiter gentilis*)
- Bull Trout (*Salvelinus confluentus*)
- Torrent Sculpin (*Cottus rhotheus*)
- Westernslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*)
- White Sturgeon (*Acipenser transmontanus*) (Kootenai River Pop.)

Risks to the Westernslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*), which is known to occur in Rainy Creek, have been presented in Section 4.1.

Fish surveys performed on site have not provided any evidence for the occurrence of either bull trout (*Salvelinus confluentus*) or torrent sculpin (*Cottus rhotheus*) in waters of OU3. Risks to fish in the Kootenai River, including the white sturgeon (*Acipenser transmontanus*), are likely to be substantially lower than in Rainy Creek, due to the lower concentrations of LA and other mine-related contaminants.

At present, no information is available to characterize the occurrence or evaluate the potential hazard to other species of special concern that might be exposed in OU3, including:

- Coeur d'Alene Salamander (*Plethodon idahoensis*)
- Boreal Toad, Green (Western Toad) (*Bufo boreas*)
- Flammulated Owl (*Otus flammeolus*)
- Northern Goshawk (*Accipiter gentilis*)
- Grizzly bears (*Ursus arctos horribilis*)
- Canada lynx (*Lynx canadensis*)

However, it is expected that species that are migratory and/or have large home ranges (larger than OU3) are likely to be at relatively low risk of exposure and effect due to the relatively low fraction of time spent in OU3. This would include the flammulated owl (migratory) and grizzly, lynx, and goshawk (large home range).

5.0 ASSESSMENT OF RISKS FROM NON-ASBESTOS CONTAMINANTS

5.1 Overview of the Assessment Strategy

Figure 5-1 provides a flow diagram that outlines a basic strategy that is often used to assess risks from non-asbestos contaminants to terrestrial receptors (plants, wildlife) at a site and to aquatic receptors (fish, invertebrates) in the surface water drainages associated with a site. Each of the steps is described below.

Toxicity Assessment

The first step in the assessment of each contaminant is usually to determine if a relevant and appropriate benchmark or toxicity reference value (TRV) exists for the chemical. If so, the chemical is typically carried to the initial HQ Sceening step (below). If there is no benchmark or TRV available, the next step is often to determine if the chemical is present at levels similar to an appropriate background or reference area. If so, no further assessment is needed. If the chemical is present at a level that appears to be elevated over background, then the chemical may be evaluated using one or more non-HQ lines of evidence, or may be identified as a source or uncertainty.

Initial HQ Screen

For non-asbestos analytes that have an appropriate benchmark or TRV, the HQ approach is usually the first line of assessment for all receptor groups. This step begins with a screening-level HQ assessment for each analyte in each medium. In this step, a maximum HQ value (HQmax) is calculated for each medium for each receptor group exposed to the medium, based on the highest detected level of each chemical in each medium. If the maximum concentration does not exceed 1.0, it is normally concluded that risks from that chemical in that medium to that receptor group are of minimal concern and that further assessment is not required.

Refined Screen

If the potential for concern for a chemical in a medium can not be excluded based on the initial HQ screen, then a refined HQ screen is usually performed next. This typically includes recalculation of HQ values based on a refined estimate of the exposure concentration (rather than just a maximum value), as well as use of refined receptor-specific exposure parameters and toxicity values (when available). The refined screen results are normally evaluated by considering the frequency and magnitude of HQ exceedences, and by reviewing the spatial pattern of exceedences. If the magnitude and frequency of HQ exceedences is low, and the data do not suggest there are any localized areas of concern, then further assessment will generally not be required.

Comparison to Background

If further assessment is required, the concentration levels seen in site samples may be compared using appropriate statistical methods to concentrations that are judged to be representative of background (natural) conditions in the area. This is most important for metals, since metals occur naturally in soil and water. It may also be useful for some organic compounds that occur naturally (alkanes, PAHs, etc.). If site levels appear to be similar to natural background levels, further assessment is usually not required. If site levels appear to be elevated above natural background, the further assessment may be warranted, as described below.

Other Lines of Evidence

If the potential for concern for a chemical in a medium can not be excluded based on the steps above, then the utility of obtaining data from other lines of investigation will be considered. This may include site-specific toxicity tests and/or community surveys. These tests, if needed, are most likely to be useful for evaluation of risks to fish from surface water, risks to benthic invertebrates from sediment, and risks to plants and soil invertebrates from soil. Further assessment of risks to wildlife receptors, if needed, may conceptually use the same techniques (site-specific toxicity testing, community surveys), although implementing these techniques for wildlife is somewhat more difficult for birds and mammals than for aquatic receptors.

5.2 Initial Screen Results Based on Phase I Data

As noted in Section 2, one round of environmental sampling (referred to as Phase I) of surface water, sediment and on-site soils has been completed at the site in the fall of 2007. These data include measurements of a wide range of non-asbestos analytes, including metals, VOCs, SVOCs, PAHs, PCBs, pesticides, radionuclides, nitrogen compounds, and anions.

It is important to note that the Phase I data alone are not considered sufficient to support the HQ-based assessment steps or background comparison step shown in Figure 5-1 because the data represent only one point in time, and may not fully capture either temporal or spatial variability at the site. For this reason, final implementation of the assessment process will not be performed until two additional rounds of environmental data (scheduled for collection in the spring and summer of 2008) are collected.

Nevertheless, the Phase I data are sufficient to provide an initial impression regarding the potential for concern from non-asbestos contaminants at the site. The results of the initial screening step performed on the Phase I data are presented below.

Surface Water

An initial screening for chemicals of potential concern (COPCs) in surface water was completed by comparing the highest measured concentration of a chemical in surface water to available aquatic toxicity screening benchmarks. The selected screening benchmarks are described in detail in Attachment C and are listed in Table 2-15. All maximum detected concentrations of metals are lower than respective benchmarks. Benchmarks are not available for either volatile or extractable hydrocarbons. These were detected at three sampling locations two of which are on seeps at Carney Creek (CCS-14 and CCS-11; Figure 2-8) and one is on Fleetwood Creek (FC-2; Figure 2-8).

Sediment

An initial screening for COPCs in sediments was completed by comparing the highest measured concentration of a chemical in sediment to respective sediment toxicity screening benchmarks. The selected screening benchmarks are described in Attachment C and are listed in Table 2-20. Maximum detected concentrations of aluminum, chromium, iron, lead, manganese, nickel, selenium and pyrene exceed respective screening benchmarks based on Threshold Effect Concentrations (TECs), and maximum detected concentrations of chromium, manganese and nickel also exceed respective benchmarks based on Probable Effect Concentrations (PECs). Benchmarks are not available for either volatile or extractable hydrocarbons.

Mine Waste and Soils

An initial screening for COPCs in soils was completed by comparing the highest measured concentration of a chemical in mine waste or soil with respective to available toxicity screening benchmarks for plants, soil invertebrates and wildlife. The selected screening benchmarks are described in detail in Attachment C and are listed in Table 2-23.

For terrestrial plants, mean and maximum detected concentrations of cobalt, copper, manganese, nickel and vanadium are higher than respective toxicity screening benchmarks. For soil invertebrates, the maximum detected concentration of manganese is higher than the toxicity screening benchmark. For wildlife, the mean and maximum detected concentrations of chromium, copper, lead and vanadium are higher than respective toxicity screening benchmarks. The maximum detected concentrations of nickel and zinc also exceed respective benchmarks. All other maximum detected concentrations are lower than respective benchmarks. Benchmarks are not available for either volatile or extractable hydrocarbons or methyl acetate.

Summary

Based on the first round of data collected in the fall of 2007, it is tentatively concluded that risks to ecological receptors are likely to be low for most non-asbestos contaminants, although a few contaminants may be of potential concern and require further assessment. Final decisions about which non-asbestos contaminants may be excluded in the initial screen and which require further assessment will be made after receipt of two additional rounds of data from the spring and summer of 2008.

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